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Right Ascensions and Declinations of Eight Stars of the Constellation Aquarius; also their probable Proper Motions. By C. J. Merfield.

Introduction.—The following coordinates in right ascension and declination, together with the most probable values of the proper motions, are the result of some inquiry necessary to establish good positions for certain stars of the constellation *Aquarius*, and used by Mr. J. Tebbutt as comparison stars when observing the minor planet (194) *Procne** during the year 1897. As these positions may be useful for other purposes, the writer presents the results to the Society.

The author has to acknowledge especially the kindness shown to him by Mr. H. C. Russell, C.M.G., for granting permission to consult the various star catalogues contained in the Library of the Sydney Observatory. Also his thanks are due to Mr. R. C. Walker, Principal Librarian for the Sydney Public Library, and to Mr. J. Tebbutt, of Windsor, for their kindly assistance.

The methods of Dr. H. S. Davis have been followed, and a *résumé* is given in the following paragraphs :—

Precession.—The year 1875 is the epoch of reduction selected. For this purpose the formulæ of Professor Hill and the constants of Peters and Struve have been adopted. These have been taken from the *Report on the Declinations of Stars employed in Latitude Work with the Zenith Telescope.*

Introducing these constants into the formulæ we have the following :—

$$\frac{d\alpha}{dt} = 3^{s}{\cdot}07225 + [0{\cdot}126115] \sin\alpha \tan\delta + \mu$$

$$\frac{d\delta}{dt} = [1{\cdot}302206] \cos\alpha + \mu'$$

$$\frac{d\mu}{dt} = [5{\cdot}9877-10]\,\mu \cos\alpha \tan\delta + [4{\cdot}8116-10]\,\mu' \sin\alpha \sec^2\delta + [4{\cdot}987-10]\,\mu\mu' \tan\delta$$

$$\frac{d^2\alpha}{dt^2} = [4{\cdot}63380_n-10]\left(\frac{d\alpha}{dt}-\mu\right) + [5{\cdot}98778-10]\left(\frac{d\alpha}{dt}+\mu\right)\cos\alpha\tan\delta + [4{\cdot}81169-10]\left(\frac{d\delta}{dt}+\mu'\right)\sin\alpha\sec^2\delta + [4{\cdot}9866-10]\,\mu\mu'\tan\delta + 0^{s}{\cdot}000\ 032\ 210$$

$$\frac{d^2\delta}{dt^2} = [4{\cdot}63380_n-10]\left(\frac{d\delta}{dt}-\mu'\right) + [7{\cdot}16387_n-10]\left(\frac{d\alpha}{dt}+\mu\right)\sin\alpha + [6{\cdot}7367_n-10]\,\mu^2\sin 2\delta$$

$$\frac{d^3\delta}{dt^3} = [2{\cdot}0987-10]\left(\frac{d\alpha}{dt}+\frac{\mu}{2}\right)\sin\alpha + [7{\cdot}1638-10]\left(\frac{d^2\alpha}{dt^2}+\frac{d\mu}{dt}\right) + [3{\cdot}0255_n-10]\left(\frac{d\alpha}{dt}+\mu\right)\left(\frac{d\alpha}{dt}\right)\cos$$

* See *Astronomical Journal*, vol. xviii. No. 420.

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in which α, δ, μ, μ' represent respectively the right ascension, declination, and the annual proper motions which have been assumed for the adopted epoch. The numbers in brackets are logarithms.

For convenience the following notation* has been adopted; that is, let

$$J = \frac{d\alpha}{dt} \qquad\qquad K = \frac{d^2\alpha}{dt^2} \times 10^2$$

$$L = \frac{d\delta}{dt} \qquad M = \frac{d^2\delta}{dt^2} \times 10^2 \qquad N = \times \frac{d^3\delta}{dt^3} \times \frac{1}{6} \times 10^6$$

Also let T be the epoch of any catalogue, and denote the right ascension and declination given in the catalogue by α_T, δ_T.

Then

$$\alpha_{1875} = \alpha_T + J(1875 - T) + K\frac{-(1875-T)^2}{200}$$

$$\delta_{1875} = \delta_T + L(1875 - T) + M\frac{-(1875-T)^2}{200} + N\left(\frac{1875-T}{100}\right)^3$$

Proper Motions.—The right ascensions or declinations given in the catalogues that have been reduced to the epoch of the catalogue with a proper motion μ_α or μ_δ have been corrected by the addition of the quantity

$$(T - t)\ (\mu - \mu_\alpha)$$

or

$$(T - t)\ (\mu' - \mu_\delta)$$

in which T denotes the epoch of the catalogue, and t the date of observation of the star. In several cases the value of t could not be found from the catalogues examined, nor could information be obtained from the libraries at disposal; the value of t has therefore been taken equal to T under such circumstances.

Systematic Corrections.—To reduce the resulting positions for 1875 to the system of the *Fundamental-Catalog für die Zonen-Beobachtungen der Astronomischen Gesellschaft*, the results of Professor Auwers have been employed, and interpolated from the tables published in the *Astronomische Nachrichten*, No. 3195–96 and 3413–14. In some cases the catalogues used have not been investigated by Auwers, so that a correction of 0·00 has been used.

* The notation of Dr. Davis has been adopted throughout, with some few alterations, to meet the requirements of this inquiry. See "Variation of Latitude of New York City."

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Weights.—To each catalogue a weight has been assigned, according to the number of observations, and based approximately upon the relative magnitude of their respective probable errors. In cases where the number of observations was not directly or otherwise obtainable, then the assumption is made that at least one observation has been taken.

Probable Errors.—The probable errors of the several deductions have been computed from the squares of the residuals by the usual formulæ. Dr. H. S. Davis has pointed out that these formulæ put the probable errors of each star on an independent basis. On the same line and in the last column of the table of results there will be found a coefficient to multiply the probable errors given, so that they will be comparable and applicable for use in combination with the probable errors of observation of other quantities. This coefficient depends on the number of catalogues used.

Formulæ for Adjustment.—The data of each catalogue give an equation of condition of the usual form

$$\sqrt{p}\{\alpha_0 - [B + \Delta\mu_0 (t - T_0)] = R\}$$

in which

p = the weight ;
α_0 = the seconds of desired mean right ascension for the epoch T_0 ;
B = the seconds of observed right ascension after the systematic correction has been applied ;
$\Delta\mu_0$ = the correction to be *subtracted* from the assumed value of μ ;
T_0 = the mean date by weight of all the observations ;
R = the residual after substituting the derived values of the unknowns.

A similar equation for the declination is obtained by replacing α_0 by δ_0 and accenting B, $\Delta\mu_0$, and R.

The solution of these equations of condition is not so laborious if the method of Professor Safford be adopted ; thus by assuming T_0 as the initial date we have

$$T_0 = \frac{[pt]}{[p]} \text{ and } \alpha_0 = \frac{[pB]}{[p]}$$

Substituting these values in the equations of condition, and letting $\alpha_0 - B = E$, $t - T_0 = C$, and $pC = D$, then

$$\Delta\mu_0 = \frac{[DE]}{[CD]}$$

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Results. Right Ascensions. Epoch 1875.

Mr. Tabbutt's Number.	Name.		Date of Observation.	Number of Observations.	Number of Catalogues.	α_{1875}			J	K	Proper Motion μ.	Probable error of α at the epoch 1875.	Probable error of μ at the date of observation.	η
			T_0	[n]	m	h	m	s	s	s	s	s	s	
11	Radcliffe	6025	1877·67	14	4	22	20	0·746	+3·1518	−0·0071	0·0000	±0·002	±0·0001	8·50
15	Radcliffe	6026	1859·60	47	12	22	20	3·216	+3·1909	−0·0093	+0·0021	±0·006	±0·0002	1·44
7	Radcliffe	6038	1877·08	12	5	22	23	56·967	+3·1242	−0·0057	+0·0052	±0·014	±0·0005	0·92
14	Radcliffe	6040	1862·78	548	40	22	24	1·845	+3·1810	−0·0088	−0·0026	±0·002	±0·0001	1·27
10	Radcliffe	6041	1869·18	20	8	22	24	44·855	+3·1404	−0·0065	+0·0076	±0·014	±0·0007	0·73
	Radcliffe	6042	1874·98	15	8	22	24	50·719	+3·1057	−0·0047	−0·0055	±0·014	±0·0006	0·73
5	Radcliffe	6073	1862·33	27	8	22	34	19·851	+3·1081	−0·0046	−0·0042	±0·017	±0·0005	0·63
6	Piazzi xxii	191	1861·98	19	8	22	35	38·343	+3·1070	−0·0045	0·0000	±0·011	±0·0004	1·06

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Declinations. Epoch 1875.

Mr. Tebbutt's Number.	Name.		Date of Observation.	Number of Observations.	Number of Catalogues.	δ_{1875}	L′	M	N	Proper Motion μ'	Probable error of δ at the epoch 1875	Probable error of μ' at the date of observation.	η'
			T_0	[n]	m	° ′ ″	″	″	″	″	″	″	
11	Radcliffe	6025	1877·67	15	4	− 8 0 42·317	+18·1758	+0·1864	−0·1693	−0·0465	±0·070	±0·0045	2·51
15	Radcliffe	6026	1857·49	43	13	−11 51 47·084	+18·1773	+0·1890	−0·1757	+0·0022	±0·099	±0·0025	1·09
7	Radcliffe	6038	1876·71	9	5	− 5 27 30·348	+18·3187	+0·1775	−0·1660	+0·0352	±0·228	±0·0089	0·78
14	Radcliffe	6040	1864·41	367	39	−11 19 1·199	+18·3216	+0·1806	−0·1747	−0·0169	±0·032	±0·0014	1·09
10	Radcliffe	6041	1869·17	22	8	− 7 11 32·250	+18·3470	+0·1770	−0·1686	−0·1258	±0·155	±0·0085	0·73
3	Radcliffe	6042	1875·63	14	7	− 3 33 3·830	+18·3504	+0·1748	−0·1631	−0·0284	±0·197	±0·0079	0·67
5	Radcliffe	6073	1863·88	27	8	− 4 12 15·540	+18·6694	+0·1575	−0·1657	−0·0319	±0·103	±0·0032	1·25
6	Piazzi xxii	191	1863·46	13	6	− 4 7 34·237	+18·7108	+0·1550	−0·1658	−0·0059	±0·075	±0·0029	2·24

Note.

Stars No. 10, 13, 14, have been used by Professor Frisby. See *Astronomical Journal*, No. 415. Radcliffe numbers refer to the 1890 Catalogue.

$$\alpha_T = \alpha_{1875} + (J' + \mu)\ (T - 1875) + K\ \frac{(T-1875)^2}{200}$$

$$\delta_T = \delta_{1875} + (L' + \mu')\ (T - 1875) + M\ \frac{(T-1875)^2}{200} + N\left(\frac{T-1875}{100}\right)^3$$

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Occultations of Ceres and of Venus, observed at the Cambridge Observatory.

(*Communicated by Professor Sir R. S. Ball, Director of the Observatory.*)

Occultation of Ceres, 1897 *November* 13.

Reappearance. First seen G.M.T. $11^h\ 31^m\ 29^s{\cdot}2$.

The observation was made with the Northumberland equatorial, aperture $11\frac{3}{4}$ in. The seeing was fair. The planet was first seen as a very unsteady and ill-defined patch of light, which grew steadily brighter, and was estimated as of full brightness 5^s after its first appearance.

Occultation of Venus, 1898 *May* 22.

Disappearance. Second contact G.M.T. $6^h\ 51^m\ 47^s{\cdot}0$.

Reappearance. Third contact G.M.T. $7^h\ 30^m\ 50^s{\cdot}1$.

The observations were made with the Northumberland equatorial. Seeing was very unsteady. First contact was missed. Bisection at disappearance was noted at $6^h\ 51^m\ 27^s$, which is uncertain by one or two seconds owing to the unsteadiness of the image. The planet lingered for several seconds as an irregular line of light, and then went out sharply, the observation of the time of second contact being noted as good. The observation of third contact was noted, "not more than half a second late, if so much." The seeing was so bad that no attempt was made to estimate the time of bisection at reappearance. The time of fourth contact was noted as $7^h\ 31^m\ 30^s$, which is uncertain by several seconds.

The observations were made by Mr. A. R. Hinks.

Cambridge Observatory:
1898 *May* 25.

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